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BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Create a Consistent Regulatory Framework for the Guidance, Planning, and Evaluation of Integrated Distributed Energy Resources	Rulemaking 14-10-003 (Filed October 2, 2014)

ADMINISTRATIVE LAW JUDGE'S RULING PROVIDING REVISED LITERATURE REVIEW

Summary

This ruling directs parties to use the attached revised version of the "*Effectiveness Tests for Evaluation of Distributed Energy Resources: A Literature Review*," as reference when addressing questions from the February 9, 2017 ruling.

Background

On February 9, 2017, a ruling was issued asking for comments on a staff proposal that recommended a societal cost test. In addition to the staff proposal, the ruling referenced an examination of how experts in the field believe cost-effectiveness may be used to evaluate distributed energy resources. The result of this examination, "Effectiveness Tests for Evaluation of Distributed Energy Resources: A Literature Review" (Literature Review), performed by the Regulatory Assistance Project (RAP), was attached to the ruling. Parties were asked to read the Literature Review in order to respond to questions at the end of the February 9, 2017 ruling.

Discussion

Following the issuance of the February 9, 2017 ruling, the assigned Administrative Law Judge was informed by Commission Energy Division that the Literature Review attached to the Ruling was not the most recent version. Specifically, the version attached to the February 9, 2017 ruling did not include an appendix, which was an annotated bibliography of the literature reviewed.

Parties should refer to the Literature Review attached to this ruling (Attachment A) when answering the four questions regarding the cost-effectiveness tests discussed in the Literature Review

IT IS RULED that parties shall use the attached version of the "*Effectiveness Tests for Evaluation of Distributed Energy Resources: A Literature Review*", performed by the Regulatory Assistance Project as reference, when answering the February 9, 2017 ruling questions regarding the cost-effectiveness tests discussed in the Literature Review.

Dated February 23, 2017 at San Francisco, California.

/s/ KELLY A. HYMES

Kelly A. Hymes
Administrative Law Judge

ATTACHMENT A

Effectiveness Tests for Evaluation of Distributed Energy Resources: A Literature Review", performed by the Regulatory Assistance Project

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Use of Cost-Effectiveness Tests for Evaluation of Distributed Energy Resources: A Literature Review

John Shenot, Carl Linvill, and Donna Brutkoski
December 2016

Introduction

Public utility commissions in virtually every state have grappled for many years with questions about how to determine if an energy efficiency resource is "cost effective." Commissions make these determinations based on the results of one or more cost-effectiveness "tests" that compare the benefits and costs of the resource. In recent years, this challenge has extended to encompass similar questions about other types of distributed energy resources (DER).

States have used a variety of different cost-effectiveness (C-E) tests to evaluate DERs. There has been – and still is – a lively debate about which tests reveal the most useful answers to questions about cost-effectiveness, and how those tests should be applied in practice. Most of the attention has fallen on three types of C-E tests that evaluate cost-effectiveness from three different perspectives. DER experts and utility theorists have vigorously debated the advantages and disadvantages of using each of these tests as the primary test for determining cost-effectiveness. Questions about how to evaluate and quantify the non-energy impacts (NEI) of DERs in each of these tests are perhaps the toughest challenge decision-makers face when they are deciding which cost-effectiveness tests to use and how to apply the tests.

Purpose of This Paper

This paper summarizes the findings of a literature review undertaken by the Regulatory Assistance Project (RAP) to examine how experts in the field believe cost-effectiveness tests ought to be used to evaluate DERs, and to assess based on the literature the strengths and weaknesses, or advantages and disadvantages, of using different tests for different purposes. The paper also summarizes current practices with respect to cost-effectiveness tests in a number of states that are leading the way in the deployment of DERs. Particular attention is given to the various ways in which NEIs are treated (or could be treated) in different cost-effectiveness tests, both in theory and in practice.

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The literature review considered cost-effectiveness tests that are or could be used to assess a wide variety of DERs, which may include energy efficiency (EE), demand response (DR), distributed generation (DG), energy storage, and plug-in electric vehicles (EV).[1]

This paper is *not* intended to serve as a general reference or manual on how to test the cost-effectiveness of DERs, nor is it intended to offer recommendations on best practices.

Appendix A provides an annotated bibliography of the papers and reports that were reviewed. In addition to the literature cited in the Appendix, a number of key decision documents produced by or for public utility commissions are noted in this summary as references on current state practices.

For What Purposes Are Cost-Effectiveness Tests Used?

In the electricity sector, C-E tests have been used for decades for a variety of purposes that correspond to different stages in the process of DER procurement:

- Measure, Project, Program and Portfolio Screening – The most basic use of any C-E test is to compare the estimated lifetime benefits and estimated lifetime costs of a DER measure, project, program or portfolio to determine if it is cost-effective (benefits exceed costs). “Measures” are discrete actions or pieces of equipment that reduce electric demand or generate electricity, such as an energy-efficient clothes washer or a plug-in EV. “Projects” involve multiple measures installed at a single location, such as a whole-house EE retrofit or a solar installation with battery storage. “Programs” are actions taken by a utility or other program administrator to encourage projects with similar characteristics, such as an air conditioner direct load control program offered to residential customers. A “portfolio” is the full suite of DER programs offered by a utility or program administrator.
- Potential Studies – Utilities, regulators, and other stakeholders commonly use C-E tests in energy efficiency potential studies to determine the “economic potential” of EE, meaning the amount of cost-effective EE that potentially could be procured. Potential studies are far less commonly used for other DER.
- Integrated Resource Plans – Utilities sometimes use the results of potential studies in a long-term resource planning process to identify the least-cost mix of resources, including DERs, that will satisfy expected future customer electricity demand. A utility may, for example, include in the long-term plan an amount of EE that has been found to be cost-effective.
- Program Plans/Procurement – Many utilities (and in some cases, other DER program administrators) are required or choose voluntarily to develop specific plans for procuring DERs. This practice is most prevalent for EE, particularly in cases where a utility is subject to a mandatory Energy Efficiency Resource Standard which requires procurement of specified amounts of EE savings. The utility or program administrator may use some form of C-E test to identify how much and what types of DER to procure, and what level of compensation or incentive to offer to customers for those DERs.
- Program Evaluation – C-E tests are also used for periodic program reviews to determine if a DER program, in its actual implementation, was as cost-effective as expected. The results of a program

[1] Cost-effectiveness tests in the electric power sector were originally developed for evaluating EE. There is a much longer history of applying these tests to EE than for other types of DER. Consequently, most of the available literature is primarily (or quite often, exclusively) focused on EE.

evaluation may be used to determine whether the program administrator has earned a performance incentive, to inform decisions about future DER program funding levels or future program offerings, or to redesign customer incentives.

Throughout our review of the literature, RAP looked for insights as to whether the experts in this field feel that different C-E tests are more or less suitable for any of the specific purposes noted above, and whether NEI should be assessed in different ways depending on the purpose of the test.

Standard Cost-Effectiveness Tests in Theory and Practice

The seminal reference document for cost-effectiveness testing in the electric power sector is the *Standard Practice Manual for Economic Analysis of Demand-Side Programs and Projects* (SPM). The SPM was originally published by the California Public Utilities Commission (CPUC) in 1983, but it has been updated multiple times in the years since. The SPM defines four C-E tests and offers a standard methodology for conducting each test. Each test considers the question of cost-effectiveness from a different perspective, and identifies categories of costs and benefits that should be included in the test. The four C-E tests described in the SPM are the Participant Test (PT), Ratepayer Impact Measure (RIM), Program Administrator Cost Test (PAC),[2] and Total Resource Cost Test (TRC). A fifth test, the Societal Cost Test (SCT), is described in the SPM as a variant of the TRC but is treated by practitioners in many other states as an entirely separate test. Consistent with much of the reviewed literature, this summary will treat the SCT as a fifth standard test rather than a variant on the TRC. The five standard C-E tests are summarized in Table 1.

Table 1: Standard C-E Tests

Test Name	Question Answered	Summary of Approach
Participant Test (PT)	Will costs decrease for the person or business participating in the DER program?	Only considers the costs and benefits experienced by program participants
Ratepayer Impact Measure (RIM)	Will utility rates decrease?	Considers the costs and benefits that affect utility rates, including program administrator costs and benefits and utility lost revenues
Program Administrator Cost Test (PAC)	Will the utility's total costs decrease?	Considers the costs and benefits experienced by the utility or program administrator

[2] Another name for the PAC test is the Utility Cost Test (UCT). Because DER programs are sometimes managed by non-utility program administrators, we opt to use the PAC name throughout this paper.

Total Resource Cost Test (TRC)	Will the sum of the utility's total costs and the participant's total costs (or energy-related costs) decrease?[3]	Considers the costs and benefits experienced by all utility customers
Societal Cost Test (SCT)	Will total costs to society decrease?	Considers all costs and benefits experienced by all members of society

Virtually all applications of C-E testing for DERs in the United States use one or more of the tests described above, but the specific categories of costs and benefits included in the calculations vary from state to state, and often vary across the different types of DERs, even while using the same name to describe the test. This is particularly true for NEIs. Quantification of NEIs can be difficult and controversial, and states have reached different conclusions about whether and how to include NEIs in the PT, TRC, and SCT. Because of all this variability, one must recognize that (for example) a TRC test in one state might be measuring different categories of costs and benefits than a TRC test in another state. Or, similarly, two states might use different names to describe tests that in practice are measuring essentially the same categories of costs and benefits (i.e., one state's TRC might be nearly the same as another state's PAC). States might even refer to their test as a "modified TRC" or come up with their own test name.

With all of those caveats in mind, Table 2 offers (for illustrative purposes only) a summary of the categories of costs and benefits that a Regulatory Assistance Project paper recommended for inclusion in each standard test when evaluating EE programs.[4] Similar summaries can be found in many of the reference works reviewed for this paper.

[3] Most states define the TRC to include all costs paid by participants and all participant benefits. But some states define the TRC (or use the TRC, in actual practice) as including only *energy-related* costs and benefits.

[4] Lazar, J., & Colburn, K. (2013). *Recognizing the Full Value of Energy Efficiency*. Montpelier, VT: Regulatory Assistance Project. Retrieved from http://www.raponline.org/knowledge-center/recognizing-the-full-value-of-energy-efficiency/?_sf_s=full+value+of+energy+efficiency.

Table 2: Categories of Costs and Benefits to Include in Each Standard C-E Test for EE Programs

Benefit (or Cost)	Refer to Section	Participant Test	RIM Test	PAC Test	TRC Test	Societal Cost Test
Energy Efficiency Program Costs	3					
Program Administration Costs (including EM&V)	3.1	-	X	X	X	X
EE Measure Costs: Program Incentives	3.1	-	X	X	X	X
EE Measure Costs: Participant Contribution	3.1	X	-	-	X	X
EE Measure Costs: Third-Party Contribution	3.1	-	-	-	X	X
Other EE Costs	3.1	X	-	X	X	X
Lost Revenues to the Utility		-	X	-	-	-
Utility System Benefits	4					
Avoided Production Capacity Costs	4.3.1.1	-	X	X	X	X
Avoided Production Energy Costs	4.3.1.2	-	X	X	X	X
Avoided Costs of Existing Environmental Regulations	4.3.1.3	-	X	X	X	X
Avoided Costs of Future Environmental Regulations	4.3.1.4	-	X	X	X	X
Avoided Transmission Capacity Costs	4.3.1.5	-	X	X	X	X
Avoided Distribution Capacity Costs	4.4	-	X	X	X	X
Avoided Line Losses	4.5	-	X	X	X	X
Avoided Reserves	4.6	-	X	X	X	X
Avoided Risk	4.7	-	X	X	X	X
Displacement of Renewable Resource Obligation	4.8	-	X	X	X	X
Reduced Credit and Collection Costs	4.9	-	X	X	X	X
Demand-Response Induced Price Effect (DRIPE)	4.10	-	X	X	X	X
Other	4.11	-	-	-	-	See Text
Benefits To Participants	5					
Other Utility Benefits to Participants	5.1	X	-	-	X	X
Other Energy Savings (fuel oil, propane, natural gas)	5.2	X	-	-	X	X
Reduced Future Energy Bills	5.3	X	-	-	-	-
Other Resource Savings (septic, well pumping, etc.)	5.4	X	-	-	X	X
Non-Energy Benefits To Participants	6					
O&M Cost Savings	6.1	X	-	-	X	X
Participant Health Impacts	6.2	X	-	-	X	X
Employee Productivity	6.3	X	-	-	X	X
Property Values	6.4	X	-	-	See Text	-
Benefits Unique to Low-Income Consumers	6.5	X	-	-	-	X
Comfort	6.6	X	-	-	X	X
Other	6.7	X	-	-	X	X
Societal Non-Energy Benefits	7					
Air Quality Impacts	7.1.1	-	-	-	-	X
Water Quantity and Quality Impacts	7.1.2	-	X	X	X	X
Coal Ash Ponds and Coal Combustion Residuals	7.1.3	-	-	-	-	X
Employment Impacts	7.2.1	-	-	-	-	X
Economic Development	7.2.2	-	-	-	-	X
Other Economic Considerations	7.2.3		X	X	X	X
Societal Risk and Energy Security	7.3	-	-	-	-	X
Reduction of Effects of Termination of Service	7.4.1	-	X	X	X	X
Avoidance of Uncollectible Bills for Utilities	7.4.2	-	X	X	X	X
Electricity/Water Nexus	8					

The complexity of C-E testing is further amplified by the fact that even where there is agreement on the categories of costs and benefits that belong in a given test, the methodologies for *quantifying* the component values will vary widely from one jurisdiction to the next. Again, this is especially true with respect to NEIs. Some states ignore NEIs, some make detailed estimates of each NEI value using complex methods, and some use “rule of thumb” or surrogate values for the NEI category as a whole in lieu of making detailed estimates.

Current C-E Testing Practices in the United States for Energy Efficiency

RAP also reviewed a variety of sources describing current C-E testing practices in the United States in order to provide benchmarks on how C-E tests are used.

The American Council for an Energy-Efficient Economy (ACEEE) maintains an online database of cost test practices used in each U.S. state for EE program planning and evaluation purposes.[5] ACEEE found that most state public utility commissions consider the results from more than one standard C-E test when they plan or evaluate EE programs. Most states identify one of the tests as a “primary” test that must reveal benefits in excess of costs or that carries more weight in decision-making. (Several states do not require benefits in excess of costs for low-income or pilot programs.) A few states don’t have EE programs or use a non-standard C-E test. Table 3 summarizes the number of states that consider each standard C-E test and how many states use each as a primary test, as of July 2016.

Table 3: Number of States Using Each Standard C-E Test for EE Program Purposes

Test Name	# of States Using Test	# of States Using as Primary Test
Participant Test (PT)	22	0
Ratepayer Impact Measure (RIM)	25	2
Program Administrator Cost Test (PAC)	31	4
Total Resource Cost Test (TRC)	38	30
Societal Cost Test (SCT)	14	5

[5] Refer to ACEEE, State and Local Policy Database, Evaluation, Measurement and Verification at http://database.aceee.org/state/evaluation-measurement-verification.

RAP took a closer look at current C-E testing practices in those states that ranked in the top 20 in *The 2015 State Energy Efficiency Scorecard* published by ACEEE.[6] The results are summarized in Table 4.

Table 4: C-E Tests Used in "Leading" States

ACEEE 2015 Scorecard Rank	State	Primary Test	Other Tests Considered
1	Massachusetts	TRC	
2	California	TRC (historically, but not currently, with some societal components)	PAC
3	Vermont	SCT	PT, PAC
4	Oregon	TRC	PAC
4	Rhode Island	TRC	
6	Connecticut	PAC	TRC
7	Maryland	TRC	PT, RIM, PAC, SCT
8	Washington	TRC (with a 10% environmental adder)	PAC
9	New York	TRC	
10	Illinois	TRC (with some societal components)	
10	Minnesota	SCT	PT, RIM, PAC

[6] Gilleo, A. et al. (2015, October). *The 2015 State Energy Efficiency Scorecard*. American Council for an Energy-Efficient Economy. Retrieved from http://aceee.org/state-policy/scorecard. RAP makes no judgment about the validity of the ranking methodology used by ACEEE. We simply used the scorecard rankings as a subjective metric for selecting a group of "leading" states that we examined more closely.

12	Colorado	TRC (with an avoided emissions value)	
12	Iowa	SCT	PT, RIM, PAC
14	D.C.	SCT	
14	Maine	TRC	
14	Michigan	PAC	
17	Arizona	SCT	
17	Pennsylvania	TRC	
19	Hawaii	TRC	
20	New Hampshire	TRC	

Several important findings are readily apparent from Table 4:

- Every leading state except Michigan uses either a TRC or SCT as one of the tests used to evaluate EE programs;
- All but two leading states (Michigan and Connecticut) make either the TRC or SCT their primary test;
- Only one leading state (Maryland) finds it useful to consider *both* the TRC and the SCT;
- Four leading states make modifications to the TRC;
- Three-fourths of the leading states don't consider the PT or RIM at all.

In addition to reviewing the tests used in each state, RAP sought additional details on how the top 5 states in the ACEEE scorecard treat EE NEIs. We also looked at Commission orders or other references for explanations of why those states have chosen to use the tests they use and why they consider (or don't consider) specific NEIs. Those results are summarized below by state:

Massachusetts

A 2009 Department of Public Utilities order (D.P.U. 08-50-A[7]) describes the Department's decision to use the TRC and clarifies how some NEIs should be treated. The Department concluded that the TRC is the test most consistent with a state statutory requirement that energy efficiency programs be less expensive than supply-side options. Furthermore, a state Supreme Court decision precluded the Department from considering the kinds of environmental externalities that would be included in an SCT evaluation. The Department opted for using just a single test (the TRC) after finding that "the incremental value that may accrue from the use of multiple cost-effectiveness tests is outweighed by the simplicity, clarity and efficiency that the continued use of a single cost-effectiveness test brings." The TRC test is to be applied at the *program* level (with limited exceptions), based on the Department's finding that "there are circumstances in which it may be appropriate for an energy efficiency program to include individual measures that are not cost-effective on their own (e.g., a measure that may be integral to the success of a program that is cost-effective; a measure that would represent a lost opportunity if not installed at the time of an installation visit; or a measure that is integral to a whole house approach to efficiency installation)."

Massachusetts includes a wide variety of NEIs in its TRC tests. In an order approving EE programs for 2013-2015 (D.P.U. 12-100 through D.P.U. 12-111[8]), the Department found that many NEIs are quantifiable and had already been quantified as a result of studies specifically ordered by the Department.[9] "Non-energy impacts are a well established component of the program cost-effectiveness analyses conducted by the Program Administrators." The Department ordered program administrators to continue including those NEIs that had been quantified in the TRC test. These include reduced operation and maintenance (O&M) costs, increased health, safety, and comfort, increased property value, and other NEIs.

In the 2009 order, the Department found that the impacts of "reasonably foreseeable environmental compliance costs" are not externalities and may be included in the TRC without running afoul of the state Supreme Court decision. The 2009 order clarifies that "the Department considers existing state law and likely federal measures to control greenhouse gases to constitute reasonably anticipated environmental compliance costs that will be reflected in future electricity prices in the Commonwealth. Consequently, the Department expects Program Administrators to include estimates of such compliance costs in the calculation of future avoided energy costs." Thus, as a state participating in the Regional Greenhouse Gas Initiative (RGGI), carbon allowance costs (and avoided costs) are factored into the TRC test but carbon externality costs are not.

The Department's 2009 order recognized the value of EE programs in promoting economic development and job benefits. However, while encouraging Program Administrators to pursue such benefits in designing their EE programs, the Department chose not to include such benefits in its C-E tests.

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[7] Massachusetts Department of Public Utilities, Docket No. 08-50-A, Investigation by the Department of Public Utilities on its own Motion into Updating its Energy Efficiency Guidelines Consistent with An Act Relative to Green Communities, March 16, 2009. Retrieved from http://ma-eeac.org/wordpress/wp-content/uploads/08-50-A-Order1.pdf.

[8] Massachusetts Department of Public Utilities, Docket Nos. 12-100 through 12-111. Petition of Western Massachusetts Electric Company, pursuant to G.L. c. 25, § 21 for approval by the Department of Public Utilities of its Three-Year Energy Efficiency Plan for 2013 through 2015.
Retrieved from http://www.mass.gov/eea/docs/dpu/electric/2013-2015-3-yr-plan-order.pdf.

[9] Specifically, NMR Group, Inc. (2011, August 15). *Massachusetts program administrators: Massachusetts special and cross-sector studies area, residential and low-income Non-Energy Impacts (NEI) evaluation*; and Tetra Tech, Inc. (2012, June 29). *Massachusetts program administrators: final report – commercial and industrial non-energy impacts study*.

California

A 2005 order by the California Public Utilities Commission (D.05-04-051) established a modified version of the TRC as the primary C-E test for most EE investments by California utilities.[10] The modification specified by the Commission was that the test should consider environmental externalities which are not typically included in a TRC test, but should not consider the full range of societal impacts or use a societal discount rate as might be typical for an SCT assessment. A 2012 order (D.12-05-015) later changed this policy to require that only the carbon allowance price be used once the California GHG cap and trade market went into effect, which happened in 2012.

The current version of the *Energy Efficiency Policy Manual*[11] adopted by the Commission specifies that C-E tests must be conducted in a manner consistent with the methods described in the SPM, as clarified in subsequent Commission decisions. In the 2005 D.05-04-051 order, the Commission chose to rely on a "dual test" wherein the modified TRC and PAC tests both play a central role. The TRC is the primary test, consistent with the Commission's view that "ratepayer-funded energy efficiency should focus on programs that serve as resource alternatives to supply-side options. The TRC measures net costs as a resource option based upon the total costs for the participants and the utility." However, the PAC is also considered because, as the 2005 order notes, "Considering the results of both the TRC and PAC tests… ensures that program administrators and program implementers do not spend more on financial incentives or rebates to participating customers than is necessary to achieve TRC benefits." In practice, the "dual test" requires that the full *portfolio* of EE programs passes *both* the TRC and the PAC, but individual EE *programs* are not required to pass either test. The rationale for applying the test at the portfolio level can be found in the above-cited 2005 order: "a portfolio level approach to evaluating cost-effectiveness and performance basis is necessary to encourage innovation and allow for some risk taking on pilot programs and/or new measures in the portfolio." Finally, California utilities have historically reported RIM and PT test results for informational purposes as part of their EE program applications, but those tests have not been used to screen EE programs.

In general, California does not explicitly include NEIs in its C-E tests for energy efficiency, but there are exceptions. First, as previously noted, in the 2006-2012 period California assigned a value to the avoided cost of greenhouse gas (GHG) emissions which was greater than the compliance costs associated with California's mandatory GHG emissions limitations. Second, California's low-income EE programs were authorized by state statutes that explicitly cite non-energy goals such as improving the health, comfort and safety of low-income ratepayers. Consequently, those types of NEIs are included in both the PT and the TRC for low-income EE programs.

California differs from many other states that don't include non-energy benefits in the TRC in that the state justifies this choice by scrupulously excluding non-energy costs as well. Whereas most leading states appear to consider the full incremental cost of an energy-efficient measure as a cost under the TRC test, California only counts the portion of the incremental measure cost (IMC) that is attributable to the energy-efficiency of the measure. So, for example, if an energy-efficient clothes washer provides the customer with energy savings, but also with water and soap savings, California tries to isolate the

[10] California Public Utility Commission. Rulemaking Docket 01-08-028. Interim Opinion: Updated Policy Rules for Post-2005 Energy Efficiency and Threshold Issues Related to Evaluation, Measurement and Verification of Energy Efficiency Programs. April 21, 2005. Retrieved from http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/45783.pdf.
[11] California Public Utility Commission. Rulemaking Docket 09-11-014. Energy Efficiency Policy Manual. Version 5. July 2013. Retrieved from http://cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/EEPolicyManualV5forPDF.pdf.

portion of the IMC for that clothes washer that "buys" the energy efficiency features and will only count that portion as a cost under the TRC.[12] Further, California CPUC staff points out that applying a net-to-gross ratio to gross savings and costs, based on a well-designed net-to-gross survey that reflects the extent to non-energy benefits (such as reduced draftiness or street noise, wanting to be more green) impacted the customer's adoption decision should exclude these types of NEIs from cost-effectiveness tests.

Vermont

The key decisions governing Vermont's use of C-E tests were originally explained in a 1990 order by the Public Service Board and a report from the hearing office in the docket.[13] The Board's decision about which C-E tests to use was facilitated by the fact that the parties to the docket were largely in agreement on C-E test issues. As the hearing officer's report notes, "To a striking degree the parties generally agreed on several important points. First, the parties were in general accord that the [SCT] should form the ultimate litmus test of resource cost-effectiveness. Second, parties agreed that the [RIM] test is not appropriate for screening demand-side programs. Third, they supported use of, but not exclusive reliance on, the [PAC] test and the [PT] in formulating demand-side tactics." The SCT was preferred on the theory that, "Maximizing society's welfare should be the primary objective of utility resource planning." However, the parties also agreed that "no single test can provide all of the relevant information needed" to decide the best resource mix. The PT was recommended as a secondary test because it reveals the strength of market barriers to efficiency investment and helps to predict customers' responses and participation rates. The PAC was seen to be useful as a secondary test because it can direct utility investment toward the greatest opportunities for demand savings, and it can sometimes serve as a simpler surrogate for the SCT.

The Board's decision in the above-cited 1990 docket clarifies that cost-effectiveness should be tested by the program administrator at the measure level as part of a pre-installation screening process, but offers assurances that the ultimate test of whether EE programs were prudently administered is at the aggregate (i.e., portfolio) level: "The aggregate used and useful test assures utilities that they need not fear disallowances after the fact for specific isolated measures that turn out to be uneconomical."

Vermont has been another of the leaders in quantifying and including NEI values in C-E test results. The origins of the Vermont approach can be found in the same 1990 Public Service Board order: "The Board concludes that failing to count costs that are known but not precisely measurable would, in effect, ignore them, thereby skewing utility resource decisions. Rather than perpetuate this implicit practice, the Hearing Officer has proposed that we exercise our discretion and judgment and set out a rebuttal presumption that will approximate true costs more accurately than the current assumption that external costs are zero… The Board accepts this recommendation, and adopts as interim adjustments a 5% adder to supply-side costs for negative externalities associated with supply sources, and a 10% discount from demand-side costs for the risk-mitigating advantages of demand-side resources."

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[12] For further discussion of this method, refer to pages 9-10 in: Rufo, M. (2014). *Perspectives on Program Influence and Cost Effectiveness: Moving Forward from the Recent US Debates.* Proceedings of the International Energy Policies and Programmes Evaluation Conference, Berlin, Germany, September 9-11, 2014. This reference document is also summarized in Appendix A.

[13] Vermont Public Service Board. Docket No. 5270. Investigation into Least-Cost Investments, Energy Efficiency, Conservation, and Management of Demand for Energy. April, 1990. Retrieved from http://psb.vermont.gov/sites/psb/files/projects/EEU/screening/5270final.pdf.

In the years since that 1990 decision, Vermont has continued to discount the costs of EE by 10% to account for risk mitigation, but has modified its approach to externalities and other NEIs. A 2012 evaluation report by the program administrator, Efficiency Vermont, illustrates the basic approach used to derive SCT results.[14] First, the program administrator now quantifies the value of many of the NEIs, including non-electric energy savings, other resource savings, O&M savings, and avoided emissions. (Like Massachusetts, Vermont participates in RGGI and distinguishes between internalized emissions costs and externality costs.) Second, the program administrator now adds to the benefits a value equal to 15% of the estimated energy and capacity benefits. This is meant to serve as a surrogate for "difficult to quantify non-energy benefits" such as greater comfort, improved health, and enhanced productivity. The goal is to eventually quantify these benefits, as well.

Oregon

The key decision document for C-E testing in Oregon dates all the way back to 1994: Docket UM 551, Order 94-590, "The Calculation and Use of Cost-Effectiveness Levels for Conservation."[15] The Commission adopted the TRC as the primary screening test for EE programs, but also decided that electric utilities should not offer incentives to customers that exceed the value of the electricity system savings. Thus, the PAC was adopted as a secondary test of cost-effectiveness. In practice, this means that the TRC is used to identify cost-effective measures but the PAC is used to determine appropriate incentive levels. These tests are applied at the *measure* level. As in most states, Oregon allows some exceptions to the cost-effectiveness requirement, for example for pilot or new technology programs.

Oregon includes non-energy benefits that accrue to the participating customer or to the utility in its TRC test if they are significant and their monetary value can be reasonably quantified. NEIs that meet this standard include water savings, O&M savings, and increased property values, but difficult to quantify NEIs like increased comfort or noise reduction are not included. Oregon also applies a broad 10% adder to the benefits of EE to account for risk, uncertainty, and known but difficult-to-quantify benefits. Finally, a $15/ton cost of carbon emissions is assumed when calculating avoided costs.

Rhode Island

The Rhode Island Public Utilities Commission held a technical session in 2014 to review that state's use of the TRC for EE program screening. Rhode Island had switched from using the PAC test to the TRC in 2009, after the Commission concluded that the TRC, being more consumer-focused than the PAC, was more consistent with the policies and goals of the state's Least Cost Procurement Act. Rhode Island applies the TRC at the measure, program, sector, and portfolio levels, but state standards technically only require the EE *programs* to be cost-effective. (Pilot programs are exempt from this requirement.) A Commission order in December 2014[16] reaffirmed use of the TRC, stating "The technical session regarding the TRC test revealed that the test is serving the purpose it was designed to serve, to evaluate the cost-effectiveness of energy efficiency measures, programs and portfolios taking into consideration

[14] Efficiency Vermont (2012, February). Annual Report 2010. Retrieved from http://www.efficiencyvermont.com/docs/about_efficiency_vermont/annual_reports/2010_Annual_Report.pdf.

[15] Documents from 1994 are not available in electronic format on the Oregon Public Utilities Commission website. However, a brochure from the Energy Trust of Oregon explains current test practices with some explanation of the rationale behind them. See Cost-Effectiveness Fact Sheet https://energytrust.org/library/GetDocument/3814.

[16] Rhode Island Public Utilities Commission. Docket #4443. Report and Order. December 31, 2014. Retrieved from http://www.ripuc.org/eventsactions/docket/4443-EERMC-Ord21767_12-31-14.pdf.

the legislative policies of this state... [T]here was no evidence to support the adoption of a different cost-effectiveness test."

A wide variety of non-energy benefits are included in the TRC used to assess EE program impacts in Rhode Island. The specific NEIs for each EE measure, expressed in dollars, are detailed in Appendix C-2 of a 2014 TRM.[17] A partial list of the categories of NEIs that are assessed include O&M savings, improved safety, thermal comfort, reduced noise, participant health benefits, property value increase, and reduced terminations and reconnections. For CHP programs, a statutory provision allows for consideration of economic development benefits and GHG reduction benefits. Like Massachusetts, Rhode Island participates in RGGI. Carbon allowance costs are included in the TRC but carbon externality costs are not listed as an NEI in the TRM.

Current C-E Testing Practices in the United States for Other DERs

RAP is not aware of any comprehensive resource comparable to the ACEEE database that summarizes whether and how states use C-E tests to evaluate other DERs. We note that some states have broadly-worded policies that apply the same C-E tests to all demand-side measures, which might in theory include DR, DG, storage and EVs. Somewhat more has been written about C-E testing for DR and DG programs, so we will conclude with a brief summary of current practices for those resources. The evolution of DR and DG evaluation and compensation in California is a subject unto itself and this national summary does not attempt to fully characterize the evolution of DR and DG valuation in California. The summary instead attempts to capture the essence of how the application of C-E tests to DR and DG resources differs from how they are typically applied to EE resources in different states where the C-E tests have been applied to two or more of these resource types.

Demand Response

Many states have processes that allow utilities to propose DR programs as stand-alone programs or in combination with EE programs as part of a larger portfolio of demand-side management programs. To the extent that these DR programs are reviewed for cost-effectiveness, they are generally subject to the same C-E tests as EE programs. Past practices suggest that the standard C-E tests are suitable and adequate for evaluating DR programs. However, a DOE and FERC-convened working group report[18] found that, "Much of the literature focuses on the benefits of demand response programs rather than cost-effectiveness frameworks for screening demand response programs."

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[17] National Grid. (2014). Rhode Island Technical Reference Manual. Retrieved from: https://www9.nationalgridus.com/non_html/eer/ri/RI%20PY2014%20TRM.pdf. That version of the TRM does not assess EE program costs (energy or non-energy). The Commission ordered the utility to revise the TRM to address costs, but was not specific about whether non-energy costs must be included.

[18] Woolf, T., Malone, E., Schwartz, L., & Shenot, J. (2013, February). *A Framework for Evaluating the Cost-Effectiveness of Demand Response*. Prepared for the National Forum on the National Action Plan on Demand Response: Cost-Effectiveness Working Group. Retrieved from http://emp.lbl.gov/sites/all/files/napdr-cost-effectiveness.pdf

Indeed, it is generally understood that DR programs present different categories of benefits and costs than EE programs, including some unique NEIs. (The DOE- and FERC-convened working group report cited above includes a recommendation on the categories to include.) The difference that is likely to have the biggest impact on C-E tests is the participant's value of lost service. Customers participating in EE programs do not lose service, while those participating in DR programs do. This value can be quite substantial, especially in the case of a manufacturer. Regulators understand that no such customer will participate in a DR program unless the compensation provided by the program administrator exceeds the full costs of participating, including that value of lost service. Therefore, it may not be necessary to consider the PT at all, while it becomes imperative that screening decisions be based on a C-E test that includes participant NEIs, like the TRC or SCT.

California offers one example of this approach. As with EE programs, California uses versions of the four SPM tests (TRC, PAC, RIM and PT) when considering DR program funding requests. The primary test is again a TRC, as it is for EE programs, but the modifications that are used for DR programs are different than the modifications used for EE programs. The same standard "avoided cost calculator" is used for both EE and DR programs to assign monetary values to energy benefits and avoided GHG emissions, but different NEIs are considered. The Commission ordered utilities to consider societal NEIs in the TRC test; utility NEIs in the TRC, PAC and RIM tests; and participant NEIs in the PT. However, only a qualitative assessment of these NEIs is mandatory (i.e., a description of the possible magnitude and impact of that cost or benefit). Quantification of NEI values is optional.

In another example, the Pacific Northwest Demand Response Project (PNDRP) developed *Guidelines for Cost-Effectiveness Valuation Framework for Demand Response Resources in the Pacific Northwest* for consideration by state utility regulators and public utility boards in the Pacific Northwest. The PNDRP guidelines recommend use of the standard C-E tests, but with modifications to account for the unique benefits and costs of DR programs.

Distributed Generation

C-E tests are rarely used to screen DG programs, but a number of utilities and state agencies (public utility commissions and energy offices) have recently completed assessments of the costs and benefits of DG programs that in many ways resemble standard C-E tests.[19] Most of these assessments have been framed as "value of solar" or "value of DG" studies. They have typically been undertaken as part of a review or reconsideration of retail rate design for customers with behind the meter DG, rather than as part of a cost-effectiveness screening process.

DG valuation studies have much in common with standard C-E test methods. A meta-analysis of value of solar studies published by Rocky Mountain Institute[20] identifies three key issues common to these studies that will look very familiar to C-E test practitioners. First, a DG valuation study establishes the perspective(s) from which value will be assessed: the participant, ratepayers (i.e., non-participants), the utility, or society. Second, the study identifies the categories of value that will be assessed. In theory,

[19] The Solar Energy Industries Association maintains a web page with links to dozens of solar cost-benefit studies. As of August 2016, this includes studies from 17 different states that are tailored to current local circumstances. See SEIA. (2016). Solar Cost-Benefit Studies. Retrieved from http://www.seia.org/policy/distributed-solar/solar-cost-benefit-studies.
[20] Hansen, L., Lacy, V., and Glick, D. (2013, September). *A Review of Solar PV Benefit & Cost Studies - 2nd Edition*. Rocky Mountain Institute. Retrieved from http://www.rmi.org/elab_empower.

these categories will be the same as the benefit and cost categories that are included in C-E tests. And third, the study explains the methods used to attach numbers to each category of value.

There are, of course, some subtle but important differences between these value of DG studies and standard C-E tests. To begin with, rather than reporting results in terms of net benefits or a benefit/cost ratio as is the norm for EE programs, value of DG studies almost always seek to estimate the net value of DG (from a specific perspective) in cents per kWh. Typically, that value is then compared not to the cost of the resource, but rather to the compensation the customer will receive under a current retail rate design. Also, with the exception of an avoided GHG emissions value, few of these studies consider NEIs. And finally, while the RIM test is only rarely used to screen EE programs, it is fairly common to find that DG valuation studies adopt a ratepayers' perspective which is more similar to the RIM test than it is to any of the other standard C-E tests.

Advantages/Disadvantages of Using Different Tests for Different Purposes and Resources

In this section, we will summarize the key points made in the literature regarding the advantages and disadvantages of using each C-E test, citing differences of opinion and in some cases referencing specific sources noted in the annotated bibliography (Appendix A).

Before considering each of the standard C-E tests, a few preliminary points that are applicable to more than one test are worth noting:

1) The vast majority of the literature focuses exclusively on the application of C-E tests to EE programs. One cannot always draw conclusions from these papers about whether the authors would apply similar reasoning and draw the same conclusions regarding other DERs.
2) Two types of differences between the tests are important to distinguish and understand:
    a. Some costs and benefits, especially NEIs, are categorically excluded from some tests but included in others.
    b. Some costs and benefits represent transfer payments between two parties. These transfer payments may end up as a benefit in one test (e.g., the PT), a cost in another (e.g., the RIM or PAC), and be absent from a third test (e.g., the TRC or SCT). For example, participant incentives appear as a benefit in the PT, a cost in the RIM and PAC, are usually absent from the TRC,[21] and are always absent from the SCT. Tests that include transfer payments tend to reflect how costs and benefits are *distributed*, rather than providing a full accounting of total economic costs and benefits. A full accounting will recognize that transfer payments are neither a cost nor a benefit.
3) As previously noted, tests as applied in practice do not always match tests as defined in theory, or there is room for interpretation of key terms. For example, the SPM states that the costs included in the TRC test are "the program costs paid by both the utility and the participants plus the increase in supply costs for the periods in which load is increased. Thus all equipment costs, installation, operation and maintenance, cost of removal (less salvage value), and administration costs, no

[21] An exception to this general statement is possible if a state has defined the TRC in a way that only *energy-related* costs and benefits for the participant are included, rather than all costs and benefits for the participant. This reflects current practice in California, for example. In such cases, an incentive payment by the utility to the participant can potentially be considered a cost rather than a transfer payment, because the energy-related benefit to the customer could be less than the cost to the utility.

matter who pays for them, are included in this test." However, in practice states vary in how they interpret these costs. Some states use a test that they call a TRC which excludes some of the participant's costs and benefits. For example, California excludes participant non-energy benefits, and attempts to balance that by *also* excluding participant non-energy costs through its energy-only incremental measure cost approach to efficiency. Because of these kinds of discrepancies, it is very important to understand whether an author is describing advantages and disadvantages of a test in theory, or as applied in a specific case.

4) State policy makers vary in the extent to which they view utility regulation as the means of achieving non-energy public policy goals. These differences of opinion on the scope of utility regulation will naturally lead to differences of opinion on how to judge the cost-effectiveness of DERs.

Participant Test (PT)

RAP found a consensus in the literature that the PT should not be used for screening DERs. The only thing a passing score on the PT tells us is that a subset of all ratepayers, namely the program participants, will benefit. A passing score offers no information about whether a DER measure or program is in the *public* interest, for all ratepayers or for society, which is rightly the focus of C-E tests used to screen programs. We found agreement in the literature that the PT should only be used for program review and program design, if used at all. The advantage of using the PT for program design is that it helps reveal the likely customer response to different participation incentive levels. DER measures with high scores on the PT are more likely to generate broad participation.

Ratepayer Impact Measure (RIM)

There is "near consensus" agreement in the published literature regarding the proper use of the RIM test for EE programs, but considerably more disagreement among stakeholders that appear before public utility regulators. Virtually all of the EE experts that have published on this topic suggest that the RIM test, like the PT, is suitable for program review and program design but not for program screening.

The advantage of the RIM test is that it indicates whether retail rates will go up or down due to DER programs. Customers, consumer advocates, and regulators are understandably and justifiably concerned with the impact of any DER program on utility rates, and this is the only C-E test that provides information on rate impacts.

However, the RIM test does not determine if a DER program is in the public interest. Like the PT, the RIM test really only determines the extent to which benefits accrue to a subset of ratepayers (in this case, non-participants). The key point is that it is the only test that treats utility lost revenues as a "cost" associated with DERs. In fact, lost revenues are not an actual cost of providing electric service, but instead represent a re-allocation of already sunk utility system costs across a smaller volume of retail sales. Another common criticism found in the literature is that using the RIM to screen DER programs is inconsistent with how decisions are made with respect to other resources. The vast majority of centralized resources that are procured by utilities put upward pressure on retail rates – not downward pressure. Those resources would fail the RIM test, were they subjected to it. But they are not. Thus, a major disadvantage of the RIM test is that it could potentially result in rejecting DERs and instead procuring utility-scale resources that would fail the RIM test by an even wider margin.

Program Administrator Cost Test (PAC)

Most of the DER cost-effectiveness experts agree on the inherent advantages and limitations of the PAC test, but they reach different conclusions about how this test compares to other C-E tests.

To begin with, the literature reflects a consensus opinion (echoed in many public utility commission decision documents) that the PAC test comes closest of all the C-E tests to reflecting the traditional focus of utility regulation on least-cost procurement of energy resources and minimizing the total costs of reliable electricity service (i.e., the revenue requirement). The PAC test aligns with the kinds of concerns that are traditionally raised by ratepayer advocates, concerns that ultimately (over the long term) translate into customer bill impacts. Virtually all of the published literature further asserts that the focus of the PAC on total long-term revenue requirements is a better gauge of the public interest than the RIM test's focus on short-term rate impacts. (We note, however, that testimony in front of public utility commissions sometimes reflects disagreement on this point, with intervenors who may not write articles in the trade journals arguing in favor of the RIM test.) Proponents of using the PAC test for DER screening say it also puts DERs on an equal footing with traditional supply-side resources procured by the utility and frames the DER transaction in very simple terms: the utility will offer customers an incentive equal to or less than the value of the DER to the utility. In states that have an inflexible, fixed budget for DER programs, the PAC test can steer the utility's limited dollars toward DER measures that have the greatest benefits for the utility system.

In addition to principled arguments for the merits of the PAC, arguments based on practicality cannot be ignored. The PAC test excludes those categories of costs and benefits that are most often described in the literature as "difficult to quantify." These include participant costs for which the program administrator may not have information, as well as participant and societal NEIs. Because those categories are excluded, the PAC test can be significantly easier to administer and less contested in its methodology than either the TRC or SCT. There is simply less controversy about what costs and benefits to include and how to evaluate them. Several articles in the literature also note that intervenors generally agree on using the utility's cost of capital as the discount rate for the PAC test, but frequently disagree on an appropriate discount rate for the TRC and SCT tests. The choice of discount rate can dramatically influence cost-effectiveness calculations, especially for long-lived DER measures.

Experts also tend to agree on the limitations or disadvantages of the PAC test. First among these limitations is the fact that certain DER programs are *explicitly* authorized – and in some cases statutorily mandated – to meet public policy goals and a definition of the "public interest" that goes beyond mere consideration of traditional energy impacts and utility costs. This could include EE programs targeted to improve the welfare of low-income customers,[22] storage programs designed to enhance community resilience, or EV programs intended to reduce emissions outside of the electric sector. For such programs, the PAC is clearly an inadequate test because it attaches no value to NEIs and doesn't answer the question of whether those programs serve the specific public interest they are intended to serve.

Many articles in the literature reviewed for this paper further argue that, even if a DER program is not intended to serve a specific non-energy public policy goal, the PAC test's exclusive focus on utility

[22] Low-income customers are less able to front the participant costs of DER measures. Public policies that seek to improve the welfare of these customers typically offer greater incentives than those offered to wealthier customers. This is important because participant costs are excluded from the PAC but included in the TRC and SCT, while customer incentives are included in the PAC but excluded from the TRC and SCT.

system costs and benefits is too limiting and doesn't serve the public interest. We will consider those arguments in the discussion of the TRC and SCT, below.

Several of the articles in the literature explicitly argue for using the PAC as the primary screening test for DERs. These include articles by Haeri & Khawaja, Neme & Kushler, and Spector & Peach that are summarized in the annotated bibliography (Appendix A). However, as noted above, only two states ranked in the top 20 on the ACEEE scorecard (and none in the top 5) currently use the PAC as their primary test for EE. Even among those experts who favor the TRC or SCT over the PAC, there is a near-universal acknowledgment of the merits of the PAC and an appreciation for the need for regulators to evaluate impacts from the utility revenue requirement perspective. In fact, some experts recommend and some leading states implement a policy that uses the TRC or SCT to screen measures and programs, but requires the full portfolio of programs to pass the PAC test. This approach gives due respect to the traditional role of utility regulation and ensures that the DER portfolio as a whole will reduce the utility's revenue requirement even if specific measures or programs do not.

Total Resource Cost Test (TRC)

Experts are clearly more divided on the advantages and disadvantages of using the TRC as a primary screening test, even if public utility commissions in leading states mostly are not. There has been substantial, ongoing debate on the merits of the TRC ever since the publication in 2010 of a paper (included in the bibliography in Appendix A) by Chris Neme and Marty Kushler, *Is It Time to Ditch the TRC*? That paper called for replacing the TRC with the PAC, largely because of the shortcomings of the TRC as perceived by the authors. It stimulated many rebuttals and concurrences, several of which are also cited in the bibliography.

Proponents of the TRC generally begin by asserting that it is a purer test of the cost-effectiveness of a DER than the PAC test, because the TRC (as practiced in most states) includes all costs and all benefits experienced *by the parties that invest in the resource*: the participant and the utility. The emphasis is on whether the resource itself is cost-effective. The PAC test, by contrast, does not consider the costs or benefits experienced by the participant, without whom there is no DER deployment. So, while the PAC might better reflect traditional views of cost-of-service utility regulation, the TRC better reflects an economist's view of cost-effectiveness. Indeed, it is widely understood that customers often participate in DER programs at least partially on the expectation of receiving non-energy benefits like non-energy resource savings, improved comfort or productivity, health benefits, etc. The literature offers many examples illustrating this point.

Indeed, a closer look at the Neme & Kushler article and most of the documents published in response to it finds that the criticisms of the TRC have less to do with its merits as applied in theory, and much more to do with its merits as applied in practice. In practice, critics of using the TRC have found that most states include all of the participant and utility costs in the equation, but exclude some or all of the participant non-energy benefits. There is a practical argument for this approach, given the widely-acknowledged difficulty in monetizing NEIs. However, when all participant costs are included but some participant benefits are excluded, the TRC becomes unbalanced and the theoretical arguments for it (i.e., it's the truest test of resource cost-effectiveness) are in jeopardy. Many studies have concluded that participant non-energy benefits comprise a sizable portion of total benefits. (See, for example, the Massachusetts and Vermont decisions cited above and the New Zealand Energy Efficiency and Conservation Authority article cited in the bibliography.) Including non-energy benefits in the TRC test can dramatically tilt C-E test results in favor of DERs. Excluding those benefits can sometimes lead to a measure failing the TRC test even while it passes the PAC test.

As noted above, California has developed an alternative approach to addressing the concerns about an unbalanced TRC test for energy efficiency.[23] Instead of achieving balance in the TRC by adding participant non-energy benefits to the equation, California achieves balance by removing participant non-energy costs from the equation. In practice, the state seeks to isolate and count only the portion of incremental measure cost (IMC) that is energy-related. The remainder of IMC is a non-energy cost.

Societal Cost Test (SCT) and Modified Versions of the TRC

The SCT has much in common with the TRC in terms of methodology, so it is not surprising that experts cite many of the same advantages and disadvantages for the SCT that they note for the TRC. In fact, these comparisons are further complicated by the fact that some states use a "modified TRC" that considers costs and benefits that in theory belong in an SCT but not a TRC test. A common example is the inclusion of an assumed value for avoided GHG emissions that reflects a "social cost of carbon" rather than a utility compliance cost.

Generally speaking, the two biggest differences between the TRC and the SCT are that the SCT considers externalities (like the social cost of carbon) and it typically uses a lower "societal discount rate" to evaluate future impacts. In the context of the SCT, any costs or benefits that are experience by parties other than the utility or the participant are externalities.

Proponents of using the SCT for DER screening typically argue that this test offers the most comprehensive and truest test of the public interest. It is the only test in which all impacts are considered – not just those experienced by the utility and the participant. Thus, it is the only test that seeks to assign any value to environmental externalities which virtually all parties to the debate acknowledge.

Critics of using the SCT for screening note that it has many of the same practicality problems as the TRC, only more so. In addition to the immense challenge of quantifying the value of utility and participant NEIs, the SCT also requires quantifying the value of societal NEIs. Some of these impacts, for example avoided GHG emissions, have been studied to the point where reasonable estimates may be possible, but many societal impacts are yet-to-be-quantified by any jurisdiction.

Several of the articles in the literature explicitly or implicitly argue for using the SCT as the primary screening test for DERs. An example can be found in the paper by Lazar & Colburn that is summarized in the annotated bibliography (Appendix A). Five states ranked in the top 20 on the ACEEE scorecard currently use the SCT as their primary test for EE, while four others use a modified TRC that includes some societal benefits.

Resource Value Framework (RVF)

The previously mentioned 2010 paper by Neme & Kushler sparked a national debate about C-E tests that continues to this day. One of the outcomes of that debate was the initiation of the National Efficiency

[23] The IMC method is currently only applied to energy efficiency in California; not DR, DG or other DERs.

Screening Project (NESP),[24] an effort coordinated by the Home Performance Coalition that involves more than 50 member organizations with an interest in DER (primarily EE) evaluation. In 2014 the NESP members released a new "Resource Value Framework" (RVF) document that outlined a set of principles and best practices for screening energy efficiency.

The RVF is not a new type of C-E test. It offers a set of principles and concepts that allow states to continue the practice of developing their own variations of the standard C-E tests, while ensuring that screening is done in a way that is explicit, transparent, balanced, and methodologically consistent. The RVF recommends applying the following principles to all C-E screening tests:

- Public interest – The ultimate objective of a test is to determine whether an efficiency resource is in the public interest. Many of the standard tests do not fully address the perspective of utility regulators, whose primary responsibility is to serve and protect the public interest. The report recommends that the primary efficiency screening test used by every state reflects a public interest perspective. The public interest perspective will include more benefits than the utility system perspective (e.g., promote customer equity, reduce risk, improve reliability, etc.), but fewer benefits than the societal perspective.
- Energy policy goals – The test should account for the energy policy goals of the state.
- Symmetry – The test should apply relevant costs and benefits symmetrically; for example, if participant costs are included, participant benefits should also be included, including non-energy benefits.
- Hard-to-quantify benefits – The test should not exclude relevant benefits because they are hard to quantify and monetize. The report recommends that benefits be monetized as much as possible, but when they are not, offers the next best options.
- Transparency – Efficiency program administrators should use a standard template to identify their state's energy policy goals and to document their assumptions and methodologies.
- Applicability – The RVF can be used in any state to determine if efficiency resources are cost-effective. It may also be applicable for evaluating other demand-side and supply-side resources, but this has not been fully examined.

The RVF report also makes related recommendations regarding best practices on topics such as quantifying avoided costs, choosing discount rates, identifying risk benefits, and picking a screening level and study period.

In addition to the framework document, the NESP members produced an RVF template that states can use to develop their C-E tests. The template lists utility system costs and benefits that the NESP members feel should be included in any screening test:

- Costs – program administration, incentives paid to participants, shareholder incentives, evaluation, and other utility costs
- Benefits – avoided energy, capacity, and T&D costs, wholesale market price suppression, avoided environmental compliance costs, and other utility system benefits).

The RVF template also lists additional categories of costs and benefits that a state may want to take into account, depending on its energy policy goals.

[24] The project website is at http://www.nationalefficiencyscreening.org/.

During the past two years, some of these RVF recommendations have been explicitly referenced and used by state public utility commissions in making C-E testing decisions.

The National Efficiency Screening Project members are currently working on a new National Standard Practice Manual for Energy Efficiency (NSPM) that will update and expand upon the California Standard Practice Manual in a manner consistent with the RVF principles. That document is expected to be published before the end of 2016.

Appendix A: Annotated Bibliography of Literature Reviewed

American Council for an Energy-Efficient Economy. (2016). *State and Local Policy Database: Evaluation, Measurement, & Verification*. Retrieved from http://database.aceee.org/state/evaluation-measurement-verification

This web page summarizes current practices in each state for evaluation, measurement, and verification of energy efficiency programs. It is one part of a state and local policy database maintained by ACEEE, and it is updated periodically as state policies change. The database identifies which cost-effectiveness tests are used in each state, and provides links to relevant state statutes, regulations, and utility commission orders.

Bluestein, J., Sreedharan, P., Tidball, R., & Price, S. (2014, November). *Using Cost-Effectiveness Tests to Design CHP Incentive Programs.* Oak Ridge National Laboratory. Retrieved from http://info.ornl.gov/sites/publications/files/Pub51866.pdf

This report argues that combined heat and power (CHP) has unique characteristics that need to be appropriately accounted for in cost-effectiveness screening. The authors believe CHP should be treated as an energy efficiency resource rather than as a supply-side resource, and they examine the structure of cost-effectiveness tests to illustrate how the tests can accurately reflect the costs and benefits of CHP systems. Cost-effectiveness results are calculated and analyzed for CHP projects in five states: Arkansas, Colorado, Iowa, Maryland, and North Carolina. Based on the results obtained for these states, the paper offers four considerations to regulators when they apply cost-effectiveness tests for CHP programs.

California Public Utilities Commission. (2001). *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects*. Retrieved from http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/CPUC_STANDARD_PRACTICE_MANUAL.pdf

The California Standard Practice Manual was originally published by the California Public Utilities Commission in 1983, but it has been updated multiple times in the years since. It defines four cost-effectiveness tests and offers a standard methodology for conducting each test. Each test considers the question of cost-effectiveness from a different perspective, and identifies categories of costs and benefits that should be included in the test. The four tests described in the manual are the Participant Test (PT), Ratepayer Impact Measure (RIM), Program Administrator Cost Test (PAC), and Total Resource Cost Test (TRC). A fifth test, the Societal Cost Test (SCT), is described in the manual as a variant of the TRC. This manual is recognized throughout the United States as the foundational reference for cost-effectiveness testing. Every state that mandates efficiency programs currently uses one or more of the tests identified in the manual to evaluate energy efficiency programs and projects, albeit in some cases with state-specific modifications.

Eckman, T. (2011). *Some Thoughts on Treating Efficiency as a Resource*. Retrieved from https://secure.in.gov/iurc/files/ACEEE_Attachment_H_Eckman_EE_as_Resource.pdf

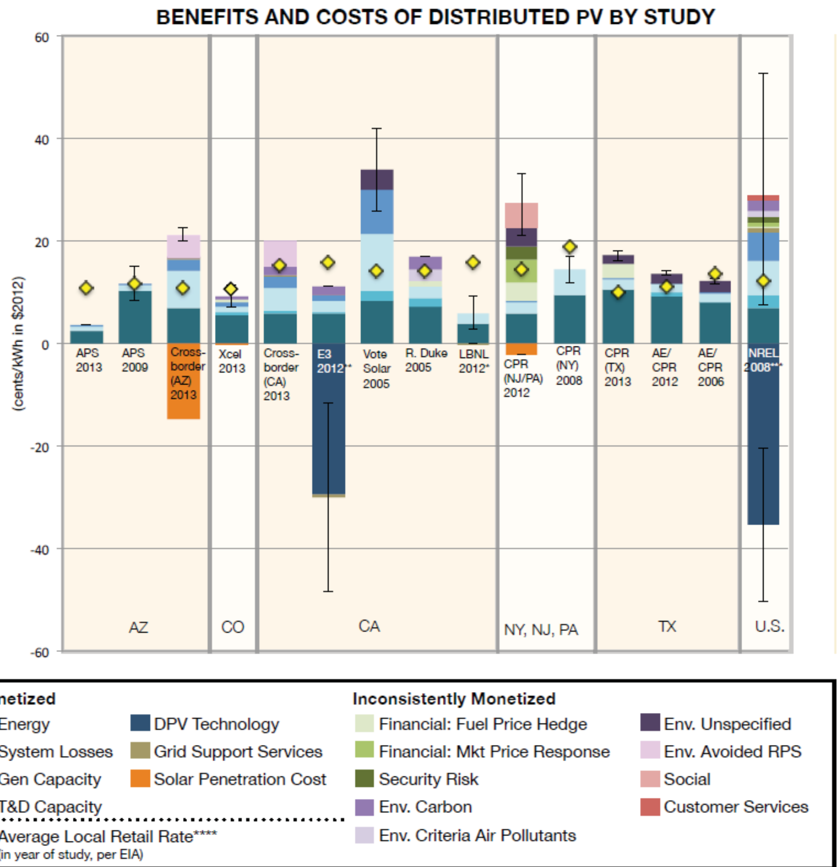
This is an updated and more comprehensive version of a paper by the same name published in *Electricity Policy*. The focus of the paper is on three elements of parity: parity in resource planning, equality in cost-effectiveness analysis, and symmetry in resource acquisition payments. The "resource planning" constraint requires that efficiency supply curves consider all costs, and not be limited to those measures assumed or likely to be cost-effective. The "cost-effectiveness analysis" element critiques the CPUC's application of the TRC test, primarily because it focuses on program costs and savings rather than resource costs and savings. The author asserts that the use of net rather than gross costs and benefits, and excluding free rider and market transformation impacts from the TRC test, ignores the fact that the energy efficiency resources procured by a utility that are excluded from net savings might still be more cost-effective than alternative generating resources. The "resource acquisition payment" discussion focuses on the requirement that utilities be prepared to pay the full cost of efficiency measures, just as they would pay the full cost of supply measures, while leaving room for below-cost payments where program achievement is not impaired.

Haeri, H., & Khawaja, M.S. (2013, July). *Valuing Energy Efficiency: The Search for a Better Yardstick*. Public Utilities Fortnightly. Retrieved from http://www.cadmusgroup.com/wp-content/uploads/2013/07/Valuing-Energy-Efficiency-Haeri_Khawaja.pdf

This article describes the limitations of using the TRC test and the approaches that have been proposed for how to modify it. The article argues that the TRC test is inadequate as a policy guide, and the PAC test is superior. The authors go on to describe the strengths of the PAC test.

Hansen, L., Lacy, V., and Glick, D. (2013, September). *A Review of Solar PV Benefit & Cost Studies - 2nd Edition*. Rocky Mountain Institute. Retrieved from http://www.rmi.org/elab_empower

This report (in the form of a slide deck with infographics) offers a meta-analysis of 16 studies by other organizations of the costs and benefits of distributed solar photovoltaic (DPV) systems. Some of the studies in the meta-analysis were produced by or for electric utilities, while others were produced by or for solar industry interests. The authors sought to understand and explain why the studies reached widely varying conclusions about the net levelized value (in cents per kilowatt-hour) of DPV. (See figure below.) They found that the studies differed in at least three major ways. First, as with any cost-effectiveness test, the stakeholder perspective from which values were calculated (i.e., participant, non-participant, utility, or societal perspective) proved to be important. Second, the categories of costs and benefits that were assessed varied across the studies. And third, the inputs, assumptions, and tools used to assign monetary values to each category of costs and benefits also varied. For each major category of value, the authors explain why and how the methodologies and results differed. The authors conclude that, "No study comprehensively evaluated the benefits and costs of DPV, although many acknowledge additional sources of benefit or cost and many agree on the broad categories of benefit and cost… While detailed methodological differences abound, there is general agreement on overall approach to estimating energy value, although there remain key differences in capacity methodology. There is significantly less agreement on overall approach to estimating grid support services and currently unmonetized values including financial and security risk, environment, and social value."



International Energy Agency. (2014). *Capturing the Multiple Benefits of Energy Efficiency.* Retrieved from http://www.iea.org/publications/freepublications/publication/capturing-the-multiple-benefits-of-energy-efficiency.html

IEA has convened a working group on multiple benefits for more than a decade; this publication summarizes this work. The benefits are identified as utility system, macroeconomic, health and well-being, industrial productivity, and energy security. The paper recommends a multi-disciplinary approach to program evaluation, so that benefits not normally evaluated by energy efficiency program managers are recognized. It explicitly includes all costs, no matter by whom paid, and recommends careful attention to free ridership in determining net energy benefits. The paper identifies the resource value framework as a potential option for consideration of multiple benefits. A short section addresses the rebound effect, noting that any rebound, by definition, includes increases in social welfare worth at least the amount paid by the consumer for energy consumed.

Itron, Inc. (2014). *2010-2012 WO017 Ex Ante Measure Cost Study Final Report*. Submitted to the California Public Utilities Commission. Regulatory Assistance Project. Retrieved from http://www.energydataweb.com/cpucFiles/pdaDocs/1100/2010-2012%20WO017%20Ex%20Ante%20Measure%20Cost%20Study%20-%20Final%20Report.pdf

This report offers documentation of how the costs of energy efficiency measures were assessed in one state. It is noted here as representative of cost studies more generally. The primary objective of the study was to provide updated and improved estimates of full and incremental measure costs for the California Public Utility Commission to use in evaluating the cost effectiveness of ratepayer-funded energy efficiency programs.

The incremental costs of mass market efficiency measures sold directly to consumers are estimated using hedonic price models which use regression analyses of actual product costs and product features to identify the incremental costs solely attributable to efficiency performance. For other measures where the use of hedonic price models was inappropriate or impossible, incremental measure costs were estimated by specialized contractors using comparable product comparisons or average values.

Kramer, C. & Reed, G. (2012). *Ten Pitfalls of Potential Studies*. Montpelier, VT: Regulatory Assistance Project. Retrieved from http://www.raponline.org/knowledge-center/ten-pitfalls-of-potential-studies/

This paper considers some of the most common and significant design considerations across potential studies and explain how these considerations impact the way in which results should be interpreted. The report also offers guidance to analysts and stakeholders on how to avoid these issues, how to correct them, and how to reinterpret the results of studies in which the issues are present. It includes chapters focused on cost-effectiveness screening and non-energy impacts, with explanations and specific examples of how the choice of tests and decisions about which non-energy impacts (NEIs) to include can significantly affect the amount of energy efficiency that is potentially cost-effective. It does not recommend any one test, but notes: "In general, if the TRC Test or [societal cost test (SCT)] is used, as many benefits as possible should be considered, because the purpose of these tests is to compare all benefits to all costs within a given jurisdiction or society as a whole. In some cases, the complexities and expense of valuing certain types of avoided costs may be prohibitive, although even in such cases a conservative fixed "adder" may be used if it is known that the benefits are at least greater than zero … [I]t is possible that the magnitude of the impact of not including NEIs in cost-effectiveness screening, as is currently the case in most jurisdictions, is rather significant. This practice may lead to a much lower number of measures passing the cost-effectiveness screen than would be the case if indeed all costs and benefits, including NEIs, were truly considered."

Kunkle, R. & Schueler, V. (2011, May). *Washington State Low-Income Weatherization Program Evaluation Report for FY2010* [Final report]. Retrieved from https://liheapch.acf.hhs.gov/pubs/WA2010FinalWx_Eval.pdf

One requirement of American Recovery and Reinvestment Act funding for enhanced low-income weatherization funding was formal evaluation. This report separately identifies energy benefits, emission benefits, economic benefits, utility system benefits, and participant benefits. The conclusion, set forth in the table below, is that the low-income weatherization program, under most assumptions was *not* cost-effective on an energy benefit basis, but *was* cost-effective if other benefits are considered. In this analysis, the nomenclature is a little unusual: "utility benefit" consists of reduced billing and collection costs, and other NEBs accruing to the utility.

Table E.1. Weatherization Program Benefits and Costs (FY2010)

Present Value	Mid	Low	High
Emissions Benefit	$380	$330	-*
Economic Benefit	$1,310	$690	$1,970
Utility Benefit	$340	$80	$680
Participant Benefit	$2,270	$920	$4,660
Total Non-Energy	$4,300	$2,020	$7,310
Energy Benefit	$4,840	$3,620	$5,680
Total Benefit	$9,140	$5,640	$12,990
Total Cost	$6,070	$6,070	$6,070
Benefit-Cost Ratio	1.5	0.9	2.1

*the emissions and economic benefit are combined in the high scenario

Larsen, P., Stuart, E., Goldman, C., & Gilligan, D. (2014). *Current Policies and Practices Related to the Incorporation of Non-Energy Benefits in Energy Saving Performance Contract Projects*. ACEEE Summer Study on Energy Efficiency in Buildings. Retrieved from http://aceee.org/files/proceedings/2014/data/papers/8-320.pdf#page=1

The authors, from Lawrence Berkeley National Laboratory and the National Association of Energy Service Companies, analyze policies and practices around incorporating the benefits of non-energy measures into energy savings performance contract (ESPC) projects implemented by energy service companies (ESCOs) in this report. In the absence of consistent guidance on methodologies for incorporating non-energy benefits into the cost/benefit analyses of projects, the report presents the results of an in-depth review of state-by-state and federal legislation on the incorporation of non-energy benefits, including measures and benefits allowed and restrictions that apply. The authors recommend standardized, simplified, and transparent methodologies for estimating and verifying the savings generated by the various non-energy measures in a manner that is analogous to the original development of the International Performance Monitoring and Verification Protocol.

Lazar, J., & Baldwin, B. (2011, August). *Valuing the Contribution of Energy Efficiency to Avoided Marginal Line Losses and Reserves.* Montpelier, VT: Regulatory Assistance Project. Retrieved from http://www.raponline.org/knowledge-center/valuing-the-contribution-of-energy-efficiency-to-avoided-marginal-line-losses-and-reserve-requirements/

This paper demonstrates that marginal line losses avoided by energy efficiency improvements are 1.5 to 2.0 times the average line losses due to the exponential nature of resistive line losses. Most cost-effectiveness studies only consider average line losses, not marginal line losses. The paper also demonstrates that 1 kW of savings at the customer meter at a critical peak hour has a value of nearly 1.5 kW of supply at the generation level, once marginal line losses and reserve requirements are considered.

Lazar, J., & Colburn, K. (2013). *Recognizing the Full Value of Energy Efficiency*. Montpelier, VT: Regulatory Assistance Project. Retrieved from http://www.raponline.org/knowledge-center/recognizing-the-full-value-of-energy-efficiency/?_sf_s=full+value+of+energy+efficiency

Commonly known as the "Layer Cake" paper based on its metaphorical depiction of multiple "layers" of benefits, this is a comprehensive look at energy efficiency valuation, focused on separate identification of utility system benefits, participant benefits, and societal benefits. It includes a detailed comparison of the PAC, TRC, and SCT, identifying which benefits are considered by which test. The paper addresses the shortcomings of the PAC test, including both the tendency to screen out many cost-effective measures by neglect of non-utility benefits, and also the tendency to screen in some non-cost-effective measures by allowing double-counting of utility system and participant benefits. It recommends use of the SCT as the primary C-E test and use of the PAC for determining appropriate incentive levels for participation.

Components of Energy Efficiency Cost-Effectiveness Tests

Benefit (or Cost)	Refer to Section	Participant Test	RIM Test	PAC Test	TRC Test	Societal Cost Test
Energy Efficiency Program Costs	3					
Program Administration Costs (including EM&V)	3.1	-	X	X	X	X
EE Measure Costs: Program Incentives	3.1	-	X	X	X	X
EE Measure Costs: Participant Contribution	3.1	X	-	-	X	X
EE Measure Costs: Third-Party Contribution	3.1	-	-	-	X	X
Other EE Costs	3.1	X	-	X	X	X
Lost Revenues to the Utility		-	X	-	-	-
Utility System Benefits	4					
Avoided Production Capacity Costs	4.3.1.1	-	X	X	X	X
Avoided Production Energy Costs	4.3.1.2	-	X	X	X	X
Avoided Costs of Existing Environmental Regulations	4.3.1.3	-	X	X	X	X
Avoided Costs of Future Environmental Regulations	4.3.1.4	-	X	X	X	X
Avoided Transmission Capacity Costs	4.3.1.5	-	X	X	X	X
Avoided Distribution Capacity Costs	4.4	-	X	X	X	X
Avoided Line Losses	4.5	-	X	X	X	X
Avoided Reserves	4.6	-	X	X	X	X
Avoided Risk	4.7	-	X	X	X	X
Displacement of Renewable Resource Obligation	4.8	-	X	X	X	X
Reduced Credit and Collection Costs	4.9	-	X	X	X	X
Demand-Response Induced Price Effect (DRIPE)	4.10	-	X	X	X	X
Other	4.11	-	-	-	-	See Text
Benefits To Participants	5					
Other Utility Benefits to Participants	5.1	X	-	-	X	X
Other Energy Savings (fuel oil, propane, natural gas)	5.2	X	-	-	X	X
Reduced Future Energy Bills	5.3	X	-	-	-	-
Other Resource Savings (septic, well pumping, etc.)	5.4	X	-	-	X	X
Non-Energy Benefits To Participants	6					
O&M Cost Savings	6.1	X	-	-	X	X
Participant Health Impacts	6.2	X	-	-	X	X
Employee Productivity	6.3	X	-	-	X	X
Property Values	6.4	X	-	-	See Text	-
Benefits Unique to Low-Income Consumers	6.5	X	-	-	-	X
Comfort	6.6	X	-	-	X	X
Other	6.7	X	-	-	X	X
Societal Non-Energy Benefits	7					
Air Quality Impacts	7.1.1	-	-	-	-	X
Water Quantity and Quality Impacts	7.1.2	-	X	X	X	X
Coal Ash Ponds and Coal Combustion Residuals	7.1.3	-	-	-	-	X
Employment Impacts	7.2.1	-	-	-	-	X
Economic Development	7.2.2	-	-	-	-	X
Other Economic Considerations	7.2.3		X	X	X	X
Societal Risk and Energy Security	7.3	-	-	-	-	X
Reduction of Effects of Termination of Service	7.4.1	-	X	X	X	X
Avoidance of Uncollectible Bills for Utilities	7.4.2	-	X	X	X	X
Electricity/Water Nexus	8					

Malmgren, I., & Skumatz, L. (2014). *Lessons from the Field: Practical Applications for Incorporating Non-Energy Benefits into Cost-Effectiveness Screening*. ACEEE Summer Study on Energy Efficiency in Buildings. Retrieved from http://aceee.org/files/proceedings/2014/data/papers/8-357.pdf#page=1

This paper presents case studies of four different types of efficiency programs, in New York, Colorado, Vermont, and the District of Columbia, with different regulatory structures and cost-effectiveness screening tools. The case studies show practical applications of how to account for non-energy benefits (NEBs) under different regulatory regimes and programmatic guidelines.

The paper examines practical applications of how these various entities were able to identify, measure, and incorporate NEBs into their cost-effectiveness screening.

National Association of Clean Air Agencies. (2015*). Implementing EPA's Clean Power Plan: A Menu of Options*. Retrieved from http://www.4cleanair.org/NACAA_Menu_of_Options

This is probably the most complete compilation of strategies for reducing emissions from the electricity sector produced in the United States. The menu of options includes 26 chapters addressing many aspects of energy efficiency, renewable energy, and grid management strategies. The key focus of the report is on the multiple benefits of many strategies, to enable air regulators to identify the most cost-effective strategies for their states to adopt in order to comply with the proposed requirements of the Clean Power Plan. The potential costs and benefits of each strategy are summarized in a standard format in each chapter. The document acknowledges the California Standard Practice Manual tests and briefly explains the different tests, but does not delve into their relative advantages and disadvantages or recommend any one test over the others.

Neme, C., & Kushler, M. (2010). *Is it Time to Ditch the TRC? Examining Concerns with Current Practice in Benefit-Cost Analysis*. 2010 ACEEE Summer Study on Energy Efficiency in Buildings.

This paper is something of a thought piece, rather than an analytical effort, identifying cases where the TRC has been inappropriately applied, or where exclusion of non-energy benefits (but inclusion of all participant and third-party costs) led to exclusion of valuable measures from utility programs. Their proposed solution is to revert to the PAC, as the utility costs and utility benefits are more easily quantified and less controversial in a regulatory setting.

New York State Department of Public Service. (2015). *Staff White Paper on Benefit-Cost Analysis in the Reforming Energy Vision Proceeding*. Report for Public Service Commission Docket 14-M-0101. Retrieved from http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={168B59A0-14A9-4DE3-8B97-DFE25A067CF9}

In support of New York's sweeping "Reforming the Energy Vision (REV)" initiative, the Public Service Commission directed its staff to develop a white paper describing a proposed benefit-cost analysis (BCA) framework for evaluating utility proposals for investments in a distributed system platform, procurement of distributed energy resources (DER) via selective processes or tariffs, and energy efficiency programs. The purpose of the framework is to enable fair evaluations of whether DERs are more cost-effective than traditional utility investments in distribution system infrastructure. The paper differs from most other papers examining cost-effectiveness issues in that it seeks to define a BCA framework applicable to all DERs (not just energy efficiency) and it pays considerably greater attention to avoided costs on the distribution system.

The white paper begins by laying out the principles to which a BCA framework should adhere. It then explains why a framework is needed to achieve the REV goals, describes how it could be employed by utilities, lists the proposed components of the framework, and offers guidance on

how to calculate the values of those components. The proposed components of the BCA framework are summarized in the table on the following page:

Table 1: List of Benefits and Costs Components to be included in BCA Framework

	BCA TEST PERSPECTIVE		
BENEFITS	**Rate Impact Measure (RIM)**	**Utility Cost (UCT)**	**Societal (SCT)**
Bulk System			
Avoided Generation Capacity (ICAP), including Reserve Margin	√	√	√
Avoided Energy (LBMP)	√	√	√
Avoided Transmission Capacity Infrastructure and related O&M	√	√	√
Avoided Transmission Losses	√	√	√
Avoided Ancillary Services (e.g. operating reserves, regulation, etc.)	√	√	√
Wholesale Market Price Impacts*	√	√	–
Distribution System			
Avoided Distribution Capacity Infrastructure	√	√	√
Avoided O&M	√	√	√
Avoided Distribution Losses	√	√	√
Reliability / Resiliency			
Net Avoided Restoration Costs	√	√	√
Net Avoided Outage Costs	–	–	√
External			
Net Avoided Green House Gases	–	–	√
Net Avoided Criteria Air Pollutants	–	–	√
Avoided Water Impacts**	–	–	√
Avoided Land Impacts**	–	–	√
Net Non-Energy Benefits (e.g. avoided service terminations, avoided uncollectible bills, health impacts, employee productivity, property values, to the extent not already included above)**	√**	√**	√**
COSTS			
Program Administration Costs (including rebates, costs of market interventions, and measurement & verification Costs)	√	√	√
Added Ancillary Service Costs	√	√	√
Incremental Transmission & Distribution and DSP Costs (including incremental metering and communications)	√	√	√
Participant DER Cost (reduced by rebates, if included above)	–	–	√
Lost Utility Revenue	√	–	–
Shareholder Incentives	√	√	–
Net Non-Energy Costs (e.g. indoor emissions, noise disturbance)**	–	–	√

* See discussion on pp. 14-15.
** These are very item- and project-specific; see discussion in the text at p. 39.

New Zealand Energy Efficiency and Conservation Authority. (2012, March 14). *Energy wise: the power to choose. Multiple benefits of energy efficiency.*

This is the summary of a four-part report on the cost-effectiveness of the New Zealand Heat-Smart program, that sought to weatherize all low-income housing in the country as a stimulus employment program for building trades, following the 2008 economic contraction. The full evaluation includes separate examinations of energy, health, and macroeconomic benefits. The most striking finding of this evaluation was not the energy benefits of the program, but the health benefits: a 43% reduction in hospital admissions due to respiratory ailments, 39% reduction in days lost at work, and a 23% reduction in days lost in school. In the simplest of terms, the program had turned leaky homes that were unaffordable to heat into comfortable homes that fostered resident health. The health benefits were found to be approximately three times as large as the energy benefits. Most evaluations of energy efficiency health benefits focus on reduced power plant emissions, while this focuses on the health improvements among the residents of the treated properties. This program also included fuel-switching from solid fuels to electric heat pumps, and is one of few reports that examines cross-fuel cost-effectiveness.

Nickerman, L., & Aslin, R. (2014). *Cost-Effectiveness Adjustments: How Effective Have States Been at Recreating the PAC?* ACEEE Summer Study on Energy Efficiency in Buildings. Retrieved from http://aceee.org/files/proceedings/2014/data/papers/8-1084.pdf#page=1

This report's authors, from Pacific Gas and Electric, explore the adjustments states have made to the TRC test in an effort to include additional benefits into the screening process that were not being captured. States have used adders and lower discount rates to account for some of these benefits, and this report quantifies the impact of these adjustments. The authors find that the adjustments can have an enormous impact on cost-effectiveness, in some cases producing net benefits that are many multiples greater than what would have been estimated under what they consider to be a standard TRC test. The report then considers how the results from the "adjusted" TRC tests compare to the standard PAC test results, and examine whether it would be simpler and produce fewer distorted results to eliminate TRC adjustments and adopt the PAC or a hybrid test as the primary cost-effectiveness screening test.

Rufo, M. (2014). *Perspectives on Program Influence and Cost Effectiveness: Moving Forward from the Recent US Debates.* Proceedings of the International Energy Policies and Programmes Evaluation Conference, Berlin, Germany, September 9-11, 2014.

This paper reviews recent literature and summarizes a range of perspectives on key issues for evaluating the cost-effectiveness of energy efficiency programs. The first part of the paper focuses on attribution, i.e., determining the extent to which gross energy savings can be legitimately attributed to the existence of an efficiency program. The second part of this paper focuses on cost-effectiveness tests and recent debates about whether the PAC should replace the TRC as the primary test used in most states. The author responds to several of the most common critiques of the TRC, including how non-energy impacts are evaluated. He asserts that an area where there appears to be some agreement is with respect to "the idea that, instead of focusing on including participants' non-energy *benefits* in the TRC, one can more easily focus on ensuring that the participants' *incremental* costs used in the TRC test include only those costs associated with the incremental efficiency of the product… Some would say that this has always been the intended definition of incremental costs as applied to use in the TRC test." He also notes that energy-related incremental measure costs are easier and less costly to estimate than energy savings, since there is not a counterfactual problem, but the challenges of doing so receive far less attention from researchers and program evaluators despite their important in evaluating cost-effectiveness.

The author recommends that program evaluators calculate cost-effectiveness using a range of tests, but "the TRC, inclusive of a full accounting of energy-based environmental externalities (especially GHG costs), [is] the most appropriate test for screening and prioritizing energy efficiency programs." He further recommends that program evaluators continue to research,

assess, and quantify non-energy impacts, but with a priority placed on those impacts that are most important to participants and to society. He also stresses the importance of incremental measure cost studies that tease out the portion of incremental costs associated with energy efficiency attributes.

Schilmoeller, M. (2011). *The Sources of Premium Value*. Northwest Power and Conservation Council. Retrieved from https://www.nwcouncil.org/media/6875198/The-sources-of-premium-value-110726.docx

This report was compiled as part of the development of the Council's Sixth Power Plan. It relies on the detailed modeling framework of the plan, in which 750 "games" are run in a Monte Carlo evaluation framework, to identify those resources and programs that are most likely to reduce the present value of system costs. The sources of premium value include capacity deferral value, fuel price and carbon risk avoidance, purchases at below market value, displacement of mandatorily-procured renewable resources, short term cost reduction, and the opportunity to purchase and resell energy savings. The principal findings are that many small resources, and in particular, resources with short lead times between the commitment of capital and the in-service dates, are highly preferable due to the avoidance of risk of overbuilding that is attendant to long-lead-time resources such as major thermal generating plants with complex siting and construction issues. The "winning" technologies are energy efficiency, distributed generating resources, and natural gas generating resources. The small resources gain about a 20 percent effective cost advantage as a result of the reduced lead time and risk.

Skumatz, L. (2010). *Non-energy benefits: status, findings, next steps, and implications for low-income program analyses in California*. Superior, CO: Economic Research Associates, Inc. Prepared for Sempra Utilities [Revised report]. Retrieved from http://www.liob.org/docs/LIEE%20Non-Energy%20Benefits%20Revised%20report.pdf

This report identifies utility system, participant, and societal benefits. The utility NEBs include avoided low-income assistance, transmission and distribution investment, health, safety, reliability, line loss, and time-of-day characteristics that are often overlooked. Participant and societal benefits include avoided hardship, noise, shutoffs, water savings, infrastructure, and national security. Skumatz recommends detailed modeling of some benefits within the utility integrated resource planning process so that they can be more fully quantified.

Spector, A., & Peach, H.G. (2014). *Natural Selection: The Evolution of DSM Valuation and Use of the UCT*. ACEEE Summer Study on Energy Efficiency in Buildings. Retrieved from http://aceee.org/files/proceedings/2014/data/papers/8-145.pdf#page=1.

This report asserts that the Utility Cost Test (UCT) – another name for the PAC test – is a more straightforward method than the TRC test for assessing utility-run natural gas demand side management activities. The declining cost of natural gas has put pressure on cost-effectiveness thresholds, and states using the TRC test have had to manage lowered avoided gas costs by applying one of several adaptive strategies. The report describes these adaptive strategies, and goes on to lay out a preferred path that embraces the PAC test instead.

State and Local Energy Efficiency Action Network. (2012). *Energy Efficiency Program Impact Evaluation Guide*. Prepared by Steven R. Schiller, Schiller Consulting, Inc. Retrieved from https://www4.eere.energy.gov/seeaction/system/files/documents/emv_ee_program_impact_guide_0.pdf.

The State and Local Energy Efficiency Action Network is a multi-stakeholder group convened by the U.S. Department of Energy and the U.S. Environmental Protection Agency. This report was produced by the network's Evaluation, Measurement, and Verification Working Group. The Guide was written as a reference document for utility regulators, program administrators, and evaluators. It explains some of the common terminology and approaches used for C-E testing and goes into details on methods for monetizing certain costs and benefits. The Guide does not recommend any specific C-E tests but discusses many of the relevant issues that should be considered when choosing a test.

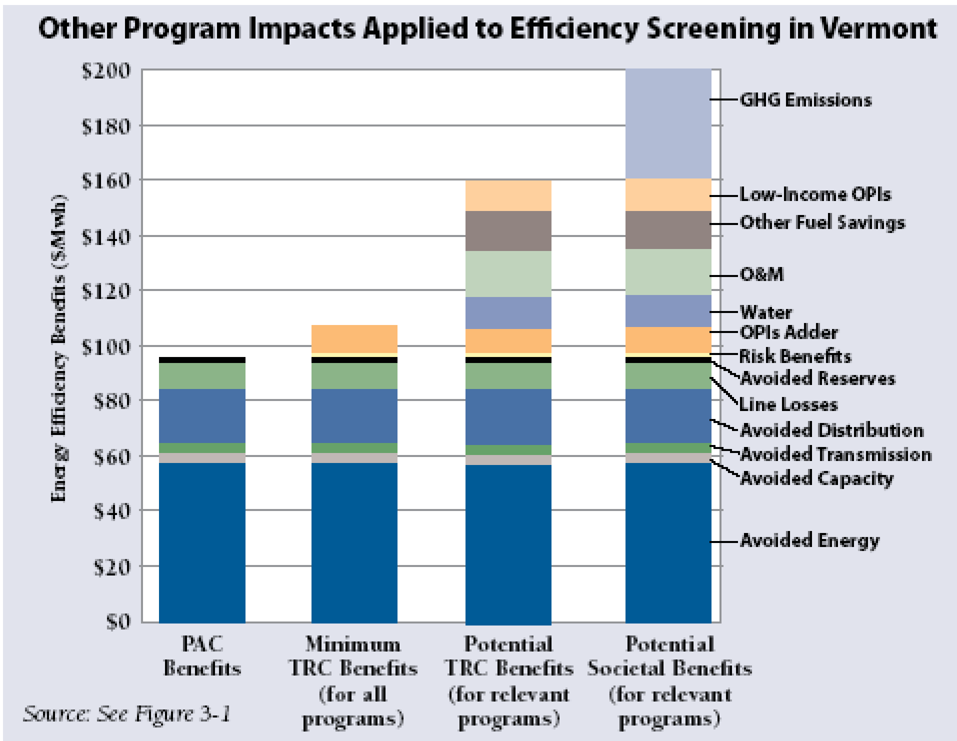
Woolf, T., Malone, E., Schwartz, L., & Shenot, J. (2013, February). *A Framework for Evaluating the Cost-Effectiveness of Demand Response*. Prepared for the National Forum on the National Action Plan on Demand Response: Cost-Effectiveness Working Group. Retrieved from http://emp.lbl.gov/sites/all/files/napdr-cost-effectiveness.pdf

This paper recommends use of all five California Standard Practice Manual tests for evaluating demand response program cost-effectiveness. "[I]n our review of the literature to date we have not seen examples of other frameworks for evaluating the cost-effectiveness of ratepayer-funded retail demand response. The California demand response protocols appear to be the most complete, the most vetted, and the most adaptable framework developed to date … The framework can be adopted for demand response purposes with minimal, albeit important modifications, and this is becoming common practice in states screening demand response programs for cost-effectiveness." The authors summarize the implications of using each test. They do not recommend any one test as preferable, but recommend against use of ratepayer impact measure (RIM) as a primary screening test.

The paper-specifies categories of demand response program impacts that should be included in each cost test and identifies several types of demand-response program impacts that do not exist or are significantly different than for energy-efficiency programs (e.g., value of lost service, potential increased energy consumption due to load shifting, emissions from backup generators, etc.). It recognizes that methodologies for quantifying costs and benefits of demand response will be different in regions where markets determine certain values (e.g., capacity value).

Woolf, T., et al. (2012). *Energy Efficiency Cost-Effectiveness Screening*. Montpelier, VT: Regulatory Assistance Project. Retrieved from http://www.raponline.org/knowledge-center/energy-efficiency-cost-effectiveness-screening/

The purpose of this report was to provide an analytical review of efficiency cost-effectiveness methodologies. Originally conceived as a counterpoint to Lazar & Colburn's *Layer Cake* paper, with a peer review framework, the authors of this report reached a conclusion that the PAC, TRC, and SCT all have a place in evaluation of cost-effectiveness, ultimately stating: "The Societal Cost Test is the most comprehensive test, and is most appropriate for those states that wish to give consideration to the societal benefits of energy efficiency programs, particularly the environmental and health benefits." The paper uses the term "other program impacts" or "OPIs" instead of non-energy benefits. Like the *Layer Cake* paper, it presents a detailed checklist of which benefits are included in which tests. The graphic below captures the differences in methods identified:



Woolf, T., Neme, C., Stanton, P., LeBaron, R., Saul-Rinaldi, K., & Cowell, S. (2014). *The Resource Value Framework: Reforming Energy Efficiency Cost-Effectiveness Screening*. The National Efficiency Screening Project. Retrieved from http://www.homeperformance.org/sites/default/files/nhpc_nesp-recommendations_20140816.pdf

The National Efficiency Screening Project is a group of organizations and individuals working to improve efficiency cost-effectiveness screening processes, and offering recommendations on their resource value framework (RVF). The report recommends states use the RVF for implementing efficiency screening tests, a set of principles and concepts that allows states to continue the practice of developing their own variations of the standard screening tests while ensuring that this is done in an explicit, transparent, balanced, and methodologically consistent way. The report offers principles that a state should adhere to when developing a test, and a template states can use to develop their test under the RVF. The template lists costs and benefits that should be included in any screening test and other costs and benefits that a state may want to take into account, depending on the state's energy policy goals. Finally, the report makes recommendations on using the standard cost-effectiveness tests, advising that the PT and RIM should not be used for screening efficiency resources, and that the other tests should be used with certain caveats.

Woolf, T., Malone, E., & Ackerman, F. (2014). *Cost-Effectiveness Screening Principles and Guidelines: For Alignment with Policy Goals, Non-Energy Impacts, Discount Rates, and Environmental Compliance Costs*. Northeast Energy Efficiency Partnerships Regional Evaluation, Measurement and Verification Forum. Retrieved from http://www.neep.org/sites/default/files/resources/Forum_C-E_Screening_Guidelines_Final_No_2014.pdf

The Northeast Energy Efficiency Partnerships (NEEP), representing nine Northeastern states and the District of Columbia, manages the Regional Evaluation, Measurement and Verification Forum, which developed this document to guide member states on cost-effectiveness screening issues. This report establishes principles that states should consider using in reviewing and improving their energy efficiency screening practices. It includes a chapter on accounting for NEIs, describing the methods for accounting for NEIs and offering states guidance on how to choose which NEIs to include in the test and how to estimate values for the NEIs. The report also recommends that efficiency screening tests account for anticipated environmental compliance costs, and offers guidance on identifying environmental requirements and determining where and how to account for them. The report also offers recommendations on how to determine the discount rate, and advises states to use a standard template to present the costs, benefits, assumptions and methodologies of their test, in order to ensure that the efficiency screening process is transparent.

(END OF ATTACHMENT A)